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Choice of Adaptation Strategies for Climate Change: The Case of Oil Palm Farmers in Southern Nigeria

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Abstract: There is an increasing concern that the performance of oil Palm production is currently, greatly threatened by climate change. Oil Palm is particularly sensitive to climate change because yields depend largely on prevailing climate conditions especially in Nigeria where traditional and rain-fed agriculture predominate. However, the extent to which these impacts are felt depends principally on the choice of adaptation measures used by farmers to cushion the effects of climate change. In the oil palm industry in Nigeria, little empirical evidence exists to substantiate the context that guides the farmer's choices of one strategy or package of strategies to employ in their effort to reduce climate change related challenges. This study adopted the multinomial logit model to analyze factors affecting the choice of adaptation strategies in response to climate extreme events. The Multinomial logit regression model was used to capture choice probabilities across the various options of climate change adaptation strategies. Results from the multinomial logit model showed that different socioeconomic factors affect adaptation to climate extreme events. Also, farm size, household size and income influenced adaptation positively while frequency of extension contact influenced adaptation negatively. The findings underscore the need for farmers' education, poverty alleviation and increased access to technologies and more efficient inputs as potent tools for climate change adaptation in the area.

Keywords: Climate Change, Adaptation Strategies, Oil Palm, Multinomial Logit Model

1. Introduction

Oil palm plays an important role in Nigeria's economic growth and development. It is a potent channel for fighting food insecurity and unemployment. Nonetheless, the continuous supply of palm produce depends critically on favorable climatic conditions. Oil palm production potential is reduced when trees are exposed to stressful weather conditions [1]. Agriculture is the most important source of livelihood for millions of people in Africa. Majority (70%) of Africa's population is involved in farming, and agricultural products cover about 40% of all exports. In addition, the percentage of Gross Domestic Product (GDP) in Africa which is generated by agriculture is about 70% [2, 3]. However, agricultural institutions have expressed concerns about the potential effects of climate change on agricultural productivity due to the fundamental role agriculture plays in the welfare of humans [4, 5]. According to [6], the variations in climatic variables, for example, amount of rainfall, temperature, wind speed, relative humidity, and sunshine duration, plays a very crucial role in determining the yields of crops. [7] and [8] projected yield reduction due to climate change and variability in some poor countries to be as much as 50% by 2020. It is noted that Africa has already experienced worsening food production and this has been a challenge in meeting the United Nations Millennium Development Goals (MDGs) of reducing hunger by half by 2015.

Nigeria's climate has been changing, evident in: increases in temperature; variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; affected fresh water resources and loss of biodiversity [9, 10, 11]. The durations and intensities of rainfall have increased, producing large runoffs and flooding in many places in Nigeria [12]. Rainfall variation is projected to continue to increase. Precipitation in southern areas is expected to rise and rising sea levels are expected to exacerbate flooding and submersion of coastal lands [10]. Droughts have also become a constant in Nigeria, and are expected to continue in Northern Nigeria, arising from a decline in precipitation and rise in temperature [13, 14]. Lake Chad and other lakes in the country are drying up and at risk of disappearing [9, 15].

Climate Change is a reality that is seriously affecting the earth already, especially challenging agricultural productivity and food security in both developed and developing economies of the world and thus requires urgent attention [16]. It is evident that climate change will have a strong impact on Nigeria, particularly in the areas of agriculture; land use, energy, biodiversity, health and water resources. Nigeria, like all the countries of Sub-Saharan Africa, is highly vulnerable to the impacts of Climate Change [8]. It was also, noted that Nigeria specifically ought to be concerned by climate change because of the country's high vulnerability due to its long (800km) coastline that is prone to sea-level rise and the risk of fierce storms. The Southwest and Southeast are relatively less vulnerable than other parts of the country. Within Southern Nigeria, the South-south (Niger Delta region) is the most vulnerable, due to sea level rise, increased precipitation, coastal erosion and flooding which has resulted in the displacement of many settlements [17, 18]. Many smallholder oil palm farmers in the oil palm industry in Nigeria depend on oil palm cultivation for their livelihood, yet there is little knowledge on sustainability of oil palm production, in the light of climate change in the oil palm producing communities in the region, as regards the actions of farmers and their ability to make choices and/or decisions given the level of knowledge and information available to them.

Increased rainfall intensity, flooding, stagnated water and polluted ground water increases outbreaks of water-borne diseases and other diseases like hepatitis and malaria commonly experienced in Southern Nigeria [10, 19]. Heavy rainfall events can also lead to contaminated drinking water from sewage, industrial and chemical waste, which can lead to the outbreak of infections [10, 20]. In parts of Southern Nigeria, for example, flooding from sea level rise has contaminated freshwater aquifers, rivers, and stock-watering points. This has increased salinity in these bodies of water and polluted them with sediment and sewage [17]. It is estimated that, in the absence of adaptation, climate change could result in a loss of between 2 to 11 percent of Nigeria's GDP by 2020, rising to between 6 to 30 percent by the year 2050. This large projected cost is the result of a wide range of climate change impacts that affect all sectors in Nigeria [20]. Consequently, it is a huge responsibility on the Nigerian government to know exactly to what extent oil palm farmers adapt to climate change effects and the extent their farms and properties are vulnerable to the ongoing climate change [21]. Concerns about adapting to global climate change are renewing the impetus for investments in agricultural research and are emerging as additional innovation practices. In the coming decades, the development and effective diffusion of new agricultural practices and technologies will largely shape how well farmers adapt to climate change [22].

To explore sustainable mechanisms to minimize the negative impact of unpredictable natural disasters due to climate change, we need to comprehend the factors that influence adaptation choices among farmers [23]. Such understanding can positively affect policy measures towards climate impact management, as well as enhance farmers' ability to cope with the negative impact of climate change on their livelihoods [24]. [25] argued that although farmers have traditionally coped with setbacks and disasters in different ways, understanding the rationale behind their chosen strategies is essential for designing incentives to encourage adaptation at the farm level. While an extensive and comprehensive body of literature on adaptation practices exists, there is a dearth of research on the factors affecting household adaptation choices, in the oil palm industry. Moreover, studies such as [26, 27, 28]. climate change, its effects and adaptation measures have received much attention but information on different types of adaptation behavior and/or choices of farmers as regards adaptation, factors that determine this behavior and /or choices, their ability to make decisions given the level of knowledge and information available to them, in the oil palm industry is very limited. This information will help policymakers determine how to encourage oil palm farmers implement various adaptation measures to protect their farms and for future intervention to address the challenges of sustainable development to climate change. Against this backdrop, this study aimed to bridge this gap in knowledge.

Therefore, the objectives of this study were: (1) To identify adaptation strategies employed by smallholder farmers to manage climate change stresses; (2) To determine the factors that influence smallholder farmers' choice of alternative sets and combinations of adaptation strategies to climate change in Southern Nigeria.

2. Materials and Method

The study area is Southern Nigeria which is made up of three geopolitical zones namely; South East, South West and South South zones. Rainfall is the key climatic variable, and there is a marked alternation of wet and dry seasons in most areas. Two air masses control rainfall - moist northward-moving maritime air coming from the Atlantic Ocean and dry continental air coming south from the African landmass. The rainy season usually begins in February or march as moist Atlantic air known as the southwest monsoon, invades the country. The beginning of the rains is usually marked by the incidence of high winds and heavy but scattered squalls. By April or early May in most years, the rainy season is underway throughout most of the area. The usual peak of the rainy season occurs through most of Southern Nigeria in July with a dip in precipitation during the month of August. Although rarely completely dry, this August dip in rainfall, which is especially marked in the south West, can be useful agriculturally, because it allows a brief dry period for grain harvesting. From September through November, the northeast trade winds generally bring a season of clear skies, moderate temperatures, and lower humidity for most of the country. From December through February, however, the northeast trade winds blow strongly and often bring with them a load of fine dust from the Sahara [29]. The area towards the North of this region is largely deforested through human activities. The vegetation is characterized by median semi deciduous forest interspersed by savannah belts that support large expanses of farmlands. Occasionally, cattle herds led by Normadic Fulani cattle raisers from Northern Nigeria can be seen on the parcels of farmlands carved out of what could be described as remnants of derived savanna [30]. Rainfall is the key climatic variable and there is a marked collection of wet and dry seasons in most areas. The greatest total precipitation is generally in the South South along the coast around bonny (South of Port Harcourt) and East of Calabar where the mean annual rainfall is more than 4,000 millimeters. Most of the South South and South East receive rainfall of 2,000 to 3,000 millimeters per year, and the Southwest (lying further north) receives lower total rainfall generally between 1,250 and 2,500 millimeters per year. The distribution of vegetation in Southern Nigeria is dependent on the climate, which becomes increasingly drier further inland from the coast. Climatic zones, therefore run parallel to the coast, widening or narrowing as geographical features alter the steepness of the climatic gradient. This climatic zoning, comprising the rain forest zone, the mixed deciduous and the parkland zone. The first two are climax systems but the parkland zone is probably caused by anthropogenic conversion of forest and is maintained by annual bush fires [29].

The study adopted the survey design. Multi-stage random sampling techniques were used to select respondents from three states (Imo, Ondo and Delta). The three states were purposively chosen based on the fact that they are major oil palm producing areas in the zone. In stage two, two agricultural zones were randomly selected from each of the selected states, making six agricultural zones (Owo and Ondo zones in Ondo state, Okigwe and Owerri zones in Imo state, and Delta Central and Delta North in Delta state). In stage three, two local government areas were randomly selected from each agricultural zone giving twelve local government areas (LGA's). In stage four, two farm communities were randomly selected from each LGA making a total of 24 communities. In the fifth stage, two villages were randomly selected from the 24 farm communities making a total of 48 villages. Finally, four farmers were randomly selected from each village giving a total sample size of 192 respondents. Data were collected from both primary and secondary sources, for year 2012. The instrument was validated by three experts in the Department of Agricultural Economics, University of Nigeria, Nsukka. The reliability of the instrument was established by a pilot test in two LGAs randomly selected in Delta state. The reliability coefficient of 0.86 was obtained using Cronbach's alpha to determine internal consistency. Data collected were analyzed using multinomial logit Model.

Data for the study were obtained from primary sources. Primary data (field survey data) were obtained using personal interview and administering of questionnaire to oil palm farmers in the study area. Data on socio-economic characteristics of oil palm farmers, perception on climate change variables, farm size, inputs, cost, annual revenues, effects of climate change on oil palm production, adaptation strategies adopted by farmers in response to these effects and all other variables hypothesized to influence the choice of adaptation strategies were collected. Care was taken to select Oil Palm fields of the sampled farmers that were planted at about the same time, that is, only farmers whose fields where about 10 years of age were selected.

3. Model Specification

Modeling choice adaptation strategies to climate change stresses.

Multinomial logistic regression was used in achieving part of objective 2. The model was stated as follows:

Let *Ai* be a random variable representing the adaptation measure chosen by any farming household. We assume that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climate attributes, socioeconomic characteristics and other factors X. The MNL model for adaptation choice specifies the following relationship between the probabilities of choosing option *Ai* and the set of explanatory variables X [31].

$$\text{Prob}\ (A_i = j) = \frac{e^{\beta_j x_i}}{\sum_{k=0}^{j} e^{\beta_j x_i}}\ ;\ j = 0, 1, \ldots, j$$

A 'universal' logit model avoids the IIA (independence of irrelevant alternatives) property while maintaining the multinomial logit form by making each ratio of probabilities a function of the attributes of all the alternatives. After considering all the economic model and interpretation, the effects of explanatory variables on the probabilities, marginal effects will be derived as:

$$\delta_j = \frac{P_j}{x_j} = P_j \left[\beta_j - \sum_{k=0}^{J} P_k \beta_k \right] = P_j(\beta_j - \bar{\beta})$$

The marginal effects measure the expected change in probability of a particular choice being made in respect to a unit change in an explanatory variable [30]. The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

In the multinomial logit model, according to [32], a set of coefficient B^1, B^2, B^3, B^4, B^5 can be estimated as:

$$\Pr(Z = 1) = \frac{e^{x\beta(1)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + e^{x\beta(5)}}$$

$$\Pr(Z = 2) = \frac{e^{x\beta(2)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + e^{x\beta(5)}}$$

$$\Pr(Z = 3) = \frac{e^{x\beta(3)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + e^{x\beta(5)}}$$

$$\Pr(Z = 4) = \frac{e^{x\beta(4)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + e^{x\beta(5)}}$$

$$\Pr(Z = 5) = \frac{e^{x\beta(5)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + e^{x\beta(5)}}$$

The model however is unidentified in the sense that there is more than one solution to $\beta^{(1)}$, $\beta^{(2)}$, $\beta^{(3)}$, $\beta^{(4)}$), $\beta^{(5)}$, that leads to the same probabilities for Z = 1, Z = 2 and Z = 3, Z = 4, Z = 5. To identify the model, one $\beta^{(1)}$, $\beta^{(2)}$, $\beta^{(3)}$, $\beta^{(4)}$, $\beta^{(5)}$ is arbitrarily set to 0. That is, if we arbitrarily set $\beta^{(4)} = 0$ the remaining coefficients $\beta^{(1)}$, $\beta^{(2)}$, $\beta^{(3)}$, $\beta^{(4)}$ would measure the change relative to the Z= 4 group. In order words we would be deterring the factors that affect farmers' choice of adaptation strategies. (1 2 3 and 4) setting $\beta^{(5)} = 0$, the above equations become:

$$\Pr(Z = 1) = \frac{e^{x\beta(1)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + 1}$$

$$\Pr(Z = 2) = \frac{e^{x\beta(2)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + 1}$$

$$\Pr(Z = 3) = \frac{e^{x\beta(3)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + 1}$$

$$\Pr(Z = 4) = \frac{e^{x\beta(4)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + 1}$$

$$\Pr(Z = 5) = \frac{e^{x\beta(5)}}{e^{x\beta(1)} + e^{x\beta(2)} + e^{x\beta(3)} + e^{x\beta(4)} + 1}$$

The relative probability of Z = 1 to base category is:

$$\frac{\Pr(Z=1)}{\Pr(Z=5)} = e^{x\beta(1)}$$

If we call this the relative likelihood and assume that X and $\beta_k^{(1)}$ are vectors equal to (x_1, x_2...; x_k) and $\beta_1^{(1)}$ $\beta_2^{(1)}$.., $\beta_k^{(1)}$ respectively. The ratio of relative likelihood for one unit change in x_i relative to the base category is then:

$$e_1^{\beta(1X)_1} + \cdots + \beta_1^{(1)}(X_1 + 1) + \cdots + \beta_k^{(1)XK} \frac{e_1^{\beta(1)}}{e_1^{\beta(1)X_1} + \cdots + \beta_1^{(1)}XK}$$

Thus, the exponential value of a coefficient is the relative likelihood ratio for one unit change in the corresponding variable as in [32]. For this study, the adaptive/adaptation strategies (response probabilities) are 9. That is, they are defined to have 9 possible values. They include: 1, denotes did nothing; 2, denoting use of resistant varieties; 3, denoting purchase of water for irrigation (for nursery); 4, denoting crop diversification; 5, denoting migration for income; 6, denoting mulching; 7, denoting changing planting dates; 8 denoting planting trees and 9 denoting multiple intercropping.

The estimation of the multinomial logit model for this study was undertaken by normalizing one category, which is normally referred to as the "reference state," or the "base category." In this study, the first category (did nothing) will be the reference state. The dependent variable (response variable) in the empirical estimation is the choice of an adaptation strategy (combination of strategies). The explanatory variables for this study include household characteristics such as education (years), age (years) of the household head, household size (no. of people in the household), farm size (ha), income level (N), distance from farm (km), extension contact (no. of visits).

4. Results and Discussions

Choice of Adaptation Practices

Table 1. *Frequency distribution of respondents according to adaptation strategies.*

Choice of practices	*No of respondents	Percentage
Use of resistance varieties	40	23.39
Mulching	21	12.28
Irrigation	37	21.63
Planting trees (afforestation)	21	12.28
Multiple cropping	17	9.94
Crop diversification	21	12.28
Changing planting dates	18	10.52
Migration for income	23	13.45
No adaptation	86	50.29

*Multiple responses indicated, Source: Field survey data (2012).

Table 1 shows that 23.39% of respondents have adopted new varieties of Oil Palm seedlings to cope with the demands of the declining agro-climatic conditions. From the table, 23 respondents chose migration for income while 86 respondents did nothing to respond to climate change effects. The result is in contrast with the findings of [16] who reported that multiple cropping and multiple planting dates were the major adaptation practices adopted by farmers in Cross River State while the least adaptation practices adopted by the farmers were mulching, irrigation and planting trees.

Actual Adaptation Strategies (choice of each adaptation practice).

Table 2. *Actual adaptation measures (choices) used by farmers (N = 171).*

Adaptation measures	*Frequency	Percentage
Use of improved technologies	79	46.19
Purchase of water for irrigation (for nursery)	37	21.63
Crop diversification	59	34.50
Migration for income	23	13.45
Did nothing (reference category)	86	50.29

*Multiple responses indicated. Source: Field survey data (2012).

Table 2 shows that 50.29 % of the respondents did nothing in their farm to respond to climate change effects. The five (5) adaptation strategies the farmers actually carry out include use of improved technologies, purchase of water for irrigation, crop diversification, migration for income and no adaptation. Hence, 5 out of the 9 mentioned strategies formed components of their actual practices.

The difference between Table 1 and Table 2 is that in Table 1, nine perceived adaptation strategies were stated as reported by farmers in the study area. In actual sense what farmers practiced as adaptation strategies was recorded in Table 2 and this formed the bases of the multinomial logit analysis. This analysis considered farmers' actual adaptation measures being taken by farmers. This can be compared with the findings of [25] on farmers' perception of climate change and adaptations using the same sample of African farmers. [33] observed that respondents who took no adaptation measures indicated lack of information and shortage of labour, land and money as major reasons for not doing so. According to [34], lack of credit services hinders farmers from getting the necessary resources and technologies which assist to adapt to climate change. Adaptation to climate change is costly and this cost could be tackled through the need for intensive labour use. Thus, if farmers do not have sufficient family labour or financial capacity to have labour, they cannot adapt. According to [35], most of the problems or constraints encountered by farmers in adapting to climate change are associated with poverty. Table 2 shows that use of improved technologies (46.19%) is the most predominant adaptation strategy. This agrees with [36] who observed that oil palm farmers were favourably disposed to the use of improved technologies particularly seedlings. Closely followed by improved technologies is crop diversification (34.50%), purchase of water for irrigation-of nursery (21.63%) and migration for income (13.45%). It is possible most farmers choose this adaptation strategy (improved technologies) because the expected profit from such an adaptation strategy is likely to exceed the expected profit without the adaptation strategy. Multiple/intercropping, planting trees were grouped in the same category as crop diversification. Use of resistant varieties, changing planting dates and mulching were grouped in the same category labeled as use of improved technologies. Similar procedures had earlier been carried out by [25, 37, 38].

5. Factors Affecting the Choice of Each Adaptation Strategies in the Area

Table 3. *Result of Multinomial logit model analysis of choices of adaptation practices by farmers.*

Explanatory variables	Use of improved technologies	Purchase of water for Irrigation	Crop diversification	Migration for income
Intercept	-8.131***(8.715)	2.838(.509)	.675(.047)	-3.544(.720)
Age	.067(2.556)	-.012(.037)	-.005(.013)	.067(1.284)
Years of Formal Education	.009(.045)	-.074(.720)	-.079(1.667)	.103(.957)
Farm Size	(1.333).119	1.052***(8.490)	-.287(1.942)	-.868**(4.229)
Household Size	.387***(15.385)	-.119(.883)	-.057(.261)	.283*(3.348)
Income	.0043(1.077)	.217*(3.669)	.079(1.844)	0.072(1.047)
Extension Visit	-3.412***(20.478)	-3.735***(10.910)	-2.566***(15.684)	-1.620(2.327)
Distance of Farm from Home	.622(.643)	-. 603(.316)	1.276(1.514)	-1.748(2.037)
Diagnostic				
X^2 = 173.54***				
-2log Likelihood = 299.338				
Pseudo R^2 = 0.68				

Note: The reference category is: did nothing.
Absolutely values t-statistics in parentheses, *significant at 10%; ** significant at 5%; *** significant at 1%. Source: Field survey data (2012).

Table 3 shows the result of multinomial logit analysis of choices of adaptation practices by farmers. The highlighted strategies in Table 1 failed to produce satisfactory results in terms of the significance level of the parameter estimates. The model was thus restructured by grouping closely related strategies together in the same category. This finding corroborates with that of [37, 38]. This section sought to describe the results of the multinomial regression predicting a vector of explanatory variables (education, age of household head, household size, farm size, income level, distance from farm and extension contact) on various adaptation strategies used by oil palm farmers. Chi-square value of 173.54 associated with the log likelihood ratio was significant ($p<0.01$) suggesting strong fit for the model.

The choice of explanatory variables for this study was based on data availability and literature. In the model, the dependent variable is the choice of an adaptation strategy. These were no adaptation, use of improved management practices, purchase of water for irrigation, crop diversification and migration for income. The base outcome (reference category) used was no adaptation.

From the results, age and years of formal education had no significant effect on any of the adaptation options. The influence of age and education on these choices (of adaptation) has been mixed in literature. This result is contrary to the findings of [39] who reported that farmers' number of years of formal education was positive and highly significantly related with the level of investment in indigenous climate change adaptation practices.

Farm size positively affected adaptation. A large farm size increased the probability of farmers purchasing water for irrigation (of their nursery) compared to doing nothing. This finding also confirmed the assertion of [40] that farmers with larger farms were found to have more land to allocate for constructing soil bunds (embankments) and improved cut-off drains. Farm size is negatively correlated with migration for income and is significant at 5% level of probability. Farm households have widely been reported to be among the poorest segments of the society. It is therefore possible that as a result of poverty, they could not maintain large farms which could lead to productivity declines thereby motivating them to migrate away from farming.

The survey found out that household size had a significant and positive effect on the use of improved technologies and migration for income. Its coefficient was 0.387 and t value of 15.385 for improved technologies. The odds ratio was 1.473. This implies that the larger the household size, the more farmers tend to use improved production technologies and migrate for income compared to farmers who did nothing. This finding corroborates to that of [41] who stated that larger family size is expected to enable farmers to take up labour intensive and adaptation measures. In comparison with those who did nothing, the odds that the farmers adopt purchase of water for irrigation as an adaptive strategy was positively and significantly related to income. This is because as the income increases, the farmers tend to increase their purchase of water as an adaptive strategy.

The likelihood of farmers using improved technologies, purchase of water for irrigation and crop diversification decreased with Extension Agents visit compared to them doing nothing. It is possible that farmers had unfavourable opinions regarding the information passed or adaptation strategies communicated to them by the extension agents. According to [42], good agents listen thoughtfully to farmer's opinion before suggesting changes. Distance from home to the farm (in km) had no significant influence on adaptation strategies. From the discrete choice model employed, results show that farm size, household size, income and frequency of extension visit are important variables in adaptation of strategies in the study area. These factors influenced adaptation positively except extension visit which influenced adaptation negatively.

6. Conclusion and Recommendations

It is evidenced from this study that oil palm farmers are experiencing change in climate and have already devised a means to survive. Results of the multinomial logit model was good. It showed that farm size ($P<0.01$), household size ($P<0.01$), income ($P<0.10$) and frequency of extension visit ($P<0.01$) are all important in explaining the choice of climate change adaptation strategies taken up by oil palm farmers in Southern Nigeria. Important adaptation options being used by farmers include crop diversification, migration for income, purchase of water for irrigation. The analysis showed the importance for the government, research units and private companies to invest resources in equipping oil palm farmers to help cushion them against further adverse climatic conditions. For instance, the government could consider giving incentives such as subsidization of input materials in order to help farmers reduce cost and expand farmland areas**.** The government can play a significant role by promoting adaptation methods appropriate for particular circumstances, e.g., particular crops for different agro-ecological zones.

With regard to education, it is important for the Nigerian government to make sure that young household members are provided with suitable education so that they are able to provide relevant advice to their elders about modern and appropriate adaptation approaches. The government, research and extension, the private sector and NGOs can improve annual revenues for smallholder farms by ensuring increase in farmer training, aid facilities and by helping farmers acquire important farm assets. Ensuring the availability and accessibility of fertilizers and crop seeds before the onset of the next cropping season can also significantly improve annual farm performances across households**.** Nevertheless, as with any form of technology, there is always the risk that adaptation measures will be more accessible to wealthier communities. Policy makers thus need to ensure that new forms of adaptation do not heighten inequality but rather contribute to a reduction in poverty

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